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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION NO. 93: APPLE ROOT-KNOT NEMATODE

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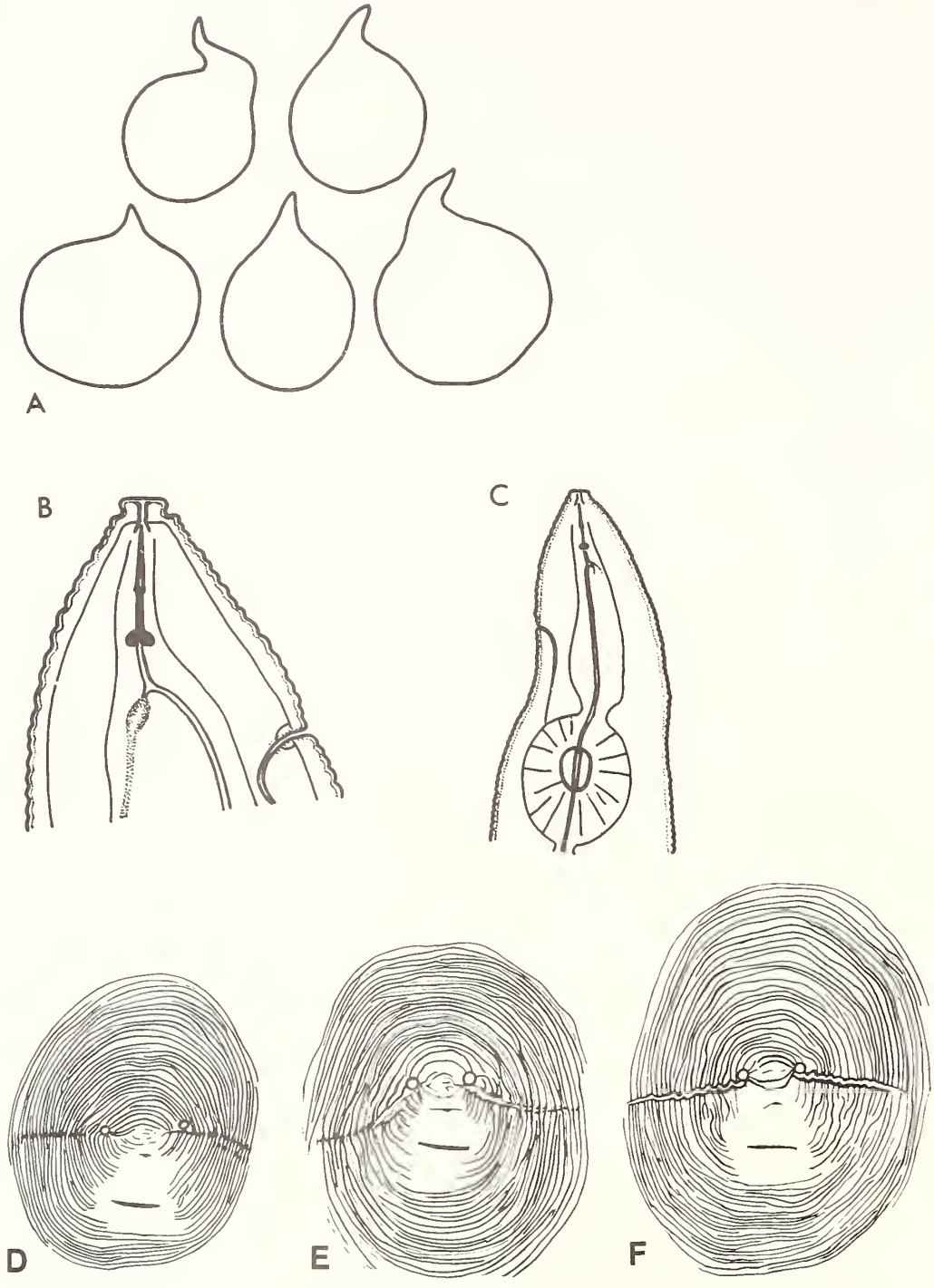
Pest	Meloidogyne mali Itoh, Ohshima, and Ichinohe, 1969
Synonyms	None
Order: Family	Tylenchida: Meloidogynidae
Economic Importance	Growth of infected apple seedlings is reduced by 15-43 percent compared to noninfected ones. Although growth differences for 36- to 50-year-old apple trees were insignificant, fruit yield is poorer from the more heavily infected trees (Inagaki 1978).
General Distribution	Japan

Meloidogyne mali distribution map (Prepared by Technical Information Systems Staff, PPQ, APHIS, USDA).

(Fig. 1)



Meloidogyne mali female. A. Entire body. B. Anterior region, lateral view. C. Anterior region of esophagus. D-F. Perineal patterns (Courtesy Japan Plant Protection Association, from Itoh et al. 1969).

Hosts

Acer palmatum, maple, Castanea crenata, Japanese chestnut, Malus prunifolia, apple (root-stock), Malus pumila, paradise apple, Malus sieboldii, apple (root-stock), Morus bombycis, mulberry, Prunus yedoensis, cherry, Rosa hybrida, rose, Trifolium repens, white clover, Vitis vinifera, wine grape (Itoh et al. 1969).

Additional hosts of M. mali reported by Toida (1979) are now known instead to be hosts of M. suginamiensis (Toida and Yaegashi 1984).

Characters

Measurements in μm from Itoh et al. (1969)

FEMALES (Fig. 1A) - Stylet length 15 (13-17), dorsal gland opening 5.5 (4-7) behind stylet base, excretory pore 23 (20-29) annules from anterior (Figs. 1B-C). Perineal pattern oval (Figs. 1D-F), striae smooth, finely spaced, dorsal arch low, flat, some pronounced transverse striae toward both ends of vulva, ventral arch flat, tail terminus forming circular striae. Phasmids large, "a distinct striae always located bending downwards spanning phasmids." Lateral fields with single or double incisures.

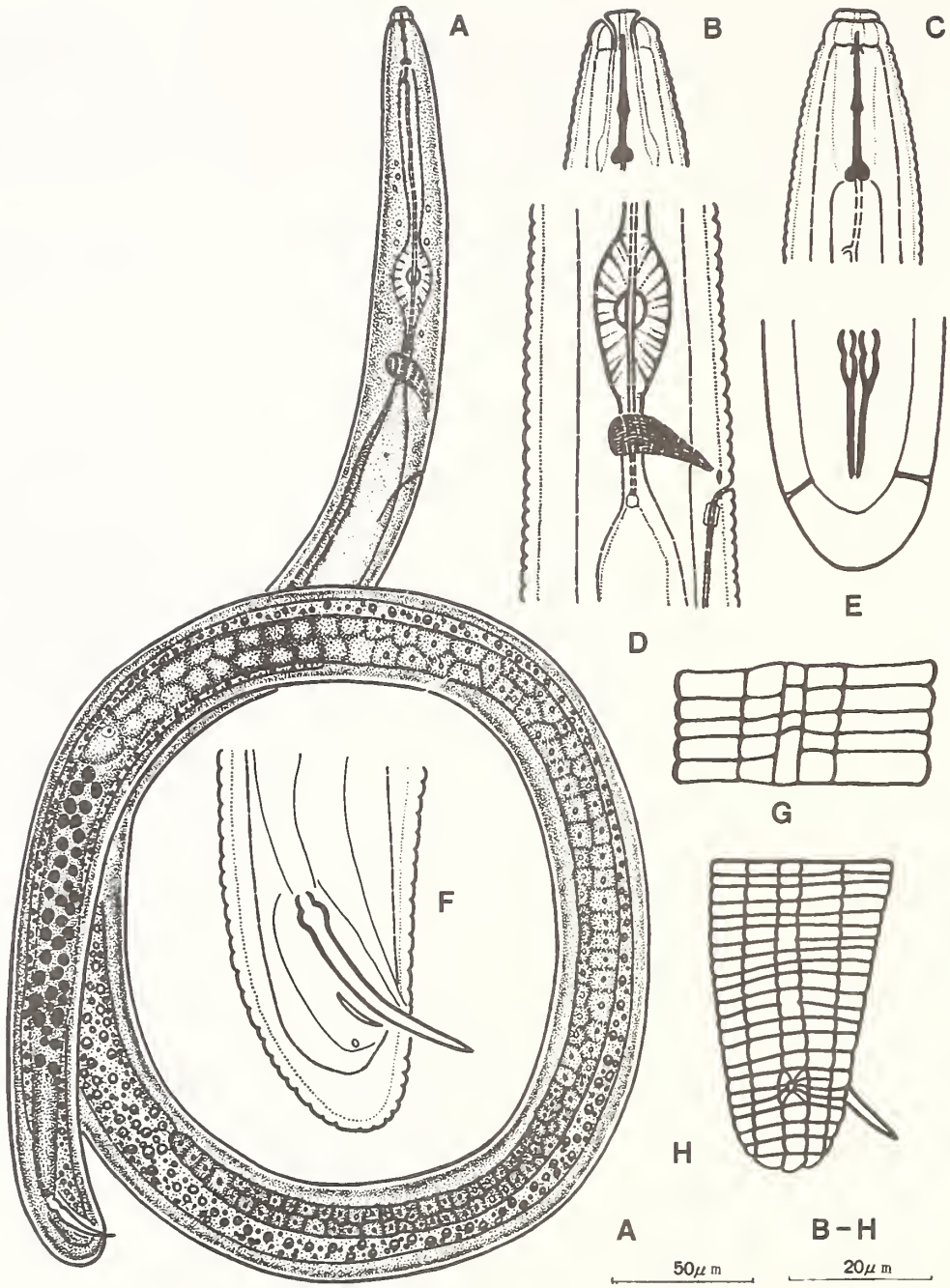
MALES (Fig. 2A) - Length 1447 (1270-1630), a = 38 (31-44), c = 40 (32-58), stylet length 20 (18-22), dorsal gland opening 8 (6-13) behind stylet base (Fig. 2C), excretory pore 20 (7-26) annules behind median bulb and 1 or 2 annules posterior to hemizonid (Fig. 2D), spicules 32 (28-35), gubernaculum 8.5 (7-10) (Fig. 2F). Lateral field with 4 incisures (Fig. 2G), areolated on tail portion (Fig. 2H).

SECOND-STAGE JUVENILES (Fig. 3A) - Length 418 (390-450), a = 28.5 (27-31), c = 13.3 (12-15), c' = 3.7 (3-5), stylet length 14 (12-15), dorsal gland opening 4.7 (4-6) behind stylet base (Fig. 3B). Tail length 31 (30-34), conoid, terminus irregular, rounded, unstriated (Figs. 3E-G). Rectum not swollen. Lateral field with 4 incisures, outer bands wider than inner band (Fig. 3H).

Characteristic Damage/Symptoms

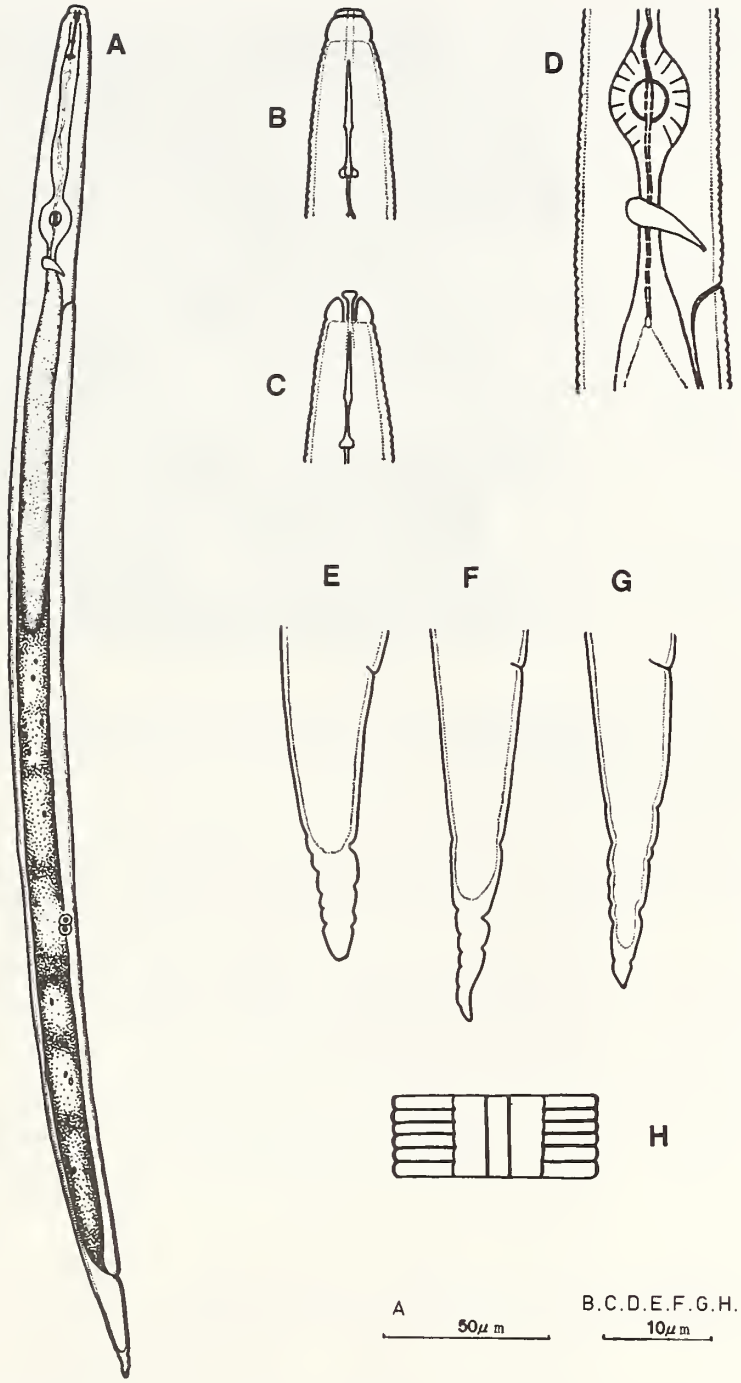
Above ground, new primary shoot growth decrease in number and length. Annual gain in plant height, trunk thickness, and numbers of leaves are reduced. Secondary shoots increase in number and length. The above ground symptoms are not specific for M. mali and may be caused by other nematodes or organisms damaging the roots. Below ground, roots exhibit the usual root-knot galls (Fig. 4) (Inagaki 1978, Sakurai et al. 1973).

(Fig. 2)



Meloidogyne mali male. A. Entire body. B. Anterior region, dorsoventral view. C. Anterior region, lateral view. D. Posterior region of esophagus. E. Tail, ventral view. F. Tail, lateral view. G. Lateral field. H. Tail, lateral surface (Courtesy Japan Plant Protection Association, from Itoh et al. 1969).

(Fig. 3)



Meloidogyne mali second-stage juvenile. A. Entire body. B. Anterior region, lateral view. C. Anterior region, dorsoventral view. D. Posterior region of esophagus. E-G. Tails. H. Lateral field (Courtesy Japan Plant Protection Association, from Itoh et al. 1969).

(Fig. 4)

Root-knots on apple roots (Courtesy Japan Plant Protection Association, from Itoh et al. 1969).

Detection Notes

In orchards, M. mali is most abundant in the top 25 cm of soil. A few nematodes occur 50 cm deep. Horizontally, the nematodes are most abundant in two zones -- 20-40 cm and 120-160 cm around the tree. These patterns of nematode distribution are thought to be related to the development and distribution of the apple roots in the soil (Inagaki 1978, Sakurai et al. 1973).

M. mali produces the characteristic root-knot nematode galls on roots of host plants. All stages of the nematode are found associated with the root galls. Eggs, infective second-stage juveniles, and males can also be found in the soil.

Males, females with head attached, and second-stage juveniles are needed for species determination. Males and juveniles should be relaxed by gentle heat before fixation in a formalin solution. Females can be fixed without heating. If galled roots are submitted for determination, males and second-stage juveniles should first be extracted by holding the roots in a moist atmosphere for several days and then relaxed and fixed.

Biology

Hatching of second-stage juveniles from eggs is negligible at 10 °C and 35 °C. At 20-30 °C, more than 80 percent hatch within 6 days. At 15 °C, hatching is delayed with 20 percent hatching in 12 days and about 60 percent hatching in 18 days (Toida 1982). The juveniles leave the egg mass and move through the soil, searching for suitable root tips to penetrate.

Many second-stage juveniles are found in apple roots 4 weeks after inoculation. Third and fourth-stage juveniles appear 4 weeks later. Both males and females appear from 12 to 20 weeks after inoculation. Egg masses are found during the 20th week, and some second-stage juveniles can be seen 2 weeks later. M. mali completes one generation in 18-22 weeks, and only one generation is produced per year in northern Japan (Inagaki 1978, Sakurai et al. 1973).

Slight swellings are observed on apple roots 6 weeks after inoculation. Many root-galls are present after the 10th week (Inagaki 1978).

Control

Applications of 8 mg of ether extracts from the leaves and stems of the Mexican marigold, Tagetes minuta, to 50 g of soil killed 70 percent of the M. mali in 24 hours. When 2 g of leaf, stem, or root tissue was applied to 50 g of soil, 50 percent of M. mali was killed in 7 days. Applying 3 g of dry leaf and stem tissue to 50 g of soil resulted in 70-90 percent kill of M. mali in 7 days (Toida and Moriyama 1978).

Rotations with nonhosts can reduce nematode populations. Nonhost plants include Capsicum annuum, pepper, Dioscorea batatas, Chinese yam, Fragaria chiloensis, Chilean strawberry, Impatiens balsamina, garden balsam, Ipomoea batatas, sweetpotato, Lycopersicon esculentum, tomato, Oryza sativa (rice), Plantago asiatica (plantain), Solanum tuberosum, potato, and Triticum aestivum, wheat (Itoh et al. 1969).

Literature Cited

Inagaki, H. Apple root-knot nematode, Meloidogyne mali, its taxonomy, ecology, damage, and control. Kasetsart J. 12(1):25-30; 1978.

Itoh, Y.; Ohshima, Y.; Ichinohe, M. A root-knot nematode, Meloidogyne mali n. sp., on apple tree from Japan (Tylenchida: Heteroderidae). Appl. Entomol. Zool. 4(4): 194-202; 1969.

Sakurai, K.; Inagaki, H.; Yuhara, I.; Tsutsumi, M. Damage and control of the apple root-knot nematode, Meloidogyne mali Itoh, Ohshima, and Ichinohe, 1969, on apple trees. Res. Bull. Hokkaido Natl. Agric. Exp. Stn. 105:9-22; 1973.

Toida, Y. Host plants and morphology of the second stage larvae of Meloidogyne mali from mulberry. Jap. J. Nematol. 9:20-24; 1979.

_____. Effect of temperature conditions on the hatching of the apple root-knot nematode, Meloidogyne mali. Jap. J. Nematol. 11:47-48; 1982.

Toida, Y.; Moriyama, H. Effects of the marigold on the control of nematodes in mulberry. 2. Nematicidal effects of the Mexican marigold by soil application. Acta Sericologica 105:129-133; 1978.

Toida, Y.; Yaegashi, T. Description of Meloidogyne suginamiensis n. sp. (Nematoda: Meloidogynidae) from mulberry in Japan. Jap. J. Nematol. 14:49-57; 1984.

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